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(12) # EUROPEAN PATENT SPECIFICATION

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(54) **Vibrating element for ultrasonic atomization.**

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EP-A-0 196 390
FR-A-2 144 347
US-A-3 373 752

(73) Proprietor: **TOA NENRYO KOGYO KABUSHIKI KAISHA**
1-1 Hitotsubashi, 1-Chome Chiyoda-Ku
Tokyo 100 (JP)

(72) Inventor: **Yonekawa, Yoshiaki**
3976-13 Fujikubo Miyoshi-machi
Iruma-gun Saitama-ken (JP)
Inventor: **Nakamura, Yoshinobu**
778-1, Shirokuwa Urawa-shi
Saitama-ken (JP)
Inventor: **Oba, Yoshiyasu**
7-307, Yakata 2-4 Shiki-shi
Saitama-ken (JP)

(74) Representative: **Slight, Geoffrey Charles et al**
Graham Watt & Co. Riverhead
Sevenoaks Kent TN13 2BN (GB)

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Description

This invention relates generally to an ultrasonic atomizing apparatus such as an ultrasonic injection nozzle, and particularly to a vibrating element for use with an ultrasonic atomizing apparatus for pulverizing liquid either intermittently or continuously. Such vibrating element may be effectively used with (1) automobile fuel injection valves such as electronically controlled gasoline injection valves and electronically controlled diesel fuel injection valves, (2) gas turbine fuel nozzles, (3) burners for use on industrial, commercial and domestic boilers, heating furnaces and stoves, (4) industrial liquid atomizers such as drying atomizers for drying liquid materials such as foods, medicines, agricultural chemicals, fertilizers and the like, spray heads for controlling temperature and humidity, atomizers for calcining powders (pelletizing ceramics), spray coaters and reaction promoting devices, and (5) liquid atomizers for uses other than industrial ones, such as spreaders for agricultural chemicals and antiseptic solution.

Ultrasonic atomizing apparatus has been widely used in place of conventional pressure spray burners or liquid spray heads in the various applications as mentioned above to atomize or pulverize liquid. The term "liquid" herein used is intended to mean not only liquid but also various liquid materials such as solution, suspension and the like.

The present applicant proposed an ultrasonic injection nozzle in EP—A—0 159 189 which had overcome the drawbacks to the injection nozzle used on the conventional spray burners or liquid spray heads as well as the prior art ultrasonic injection nozzle.

The ultrasonic injection nozzle as disclosed in the aforesaid patent application comprises an ultrasonic vibration generating means, and an elongated vibrating element connected at one end to said ultrasonic vibration generating means and having an edged portion at the other end, said edged portion being supplied with liquid for pulverization.

It has been found that such ultrasonic injection nozzle is capable of pulverizing a large quantity of liquid intermittently or continuously and may be used very effectively in the various applications stated above.

It has been found through further studies and experiments that in such ultrasonic injection nozzle as well, the configuration of the vibrating element has a great effect on the amount of liquid which the nozzle is capable of atomizing.

In EP—A—0 196 390 which falls under Art. 54(3) EPC, the present applicant describes a vibrating element for ultrasonic atomization having an edged portion formed around the outer periphery of the element, to be supplied with liquid to be pulverized, said edged portion having projecting steps each defining an edge.

In EP—A—0 187 490 which falls under Art. 54(3) EPC, the present applicant describes a similar vibrating element wherein the edged portion is formed around an inner periphery. In this case, the edges of the steps have either the same diameter or progressively increasing diameters.

FR—A—2 144 347 discloses a device for ultrasonic atomization of liquid fuels employing a vibrating element having a nozzle and a passage for liquid fuel under pressure to be supplied to the nozzle and which is equipped with a swirl plug having helical surface grooves which co-operate with the passage wall to provide helical passages for imparting a swirling motion to the liquid fuel going to the nozzle.

The present invention provides a vibrating element for ultrasonic atomization having an edged portion formed around an inner or an outer periphery of an outer end of the element, to be supplied with liquid to be pulverized, said edged portion having projecting steps each defining an edge, the edges of the steps in the case of inner peripheral steps, having the same or progressively increasing diameters, the steps being formed by helical screw thread turns.

Specific embodiments of the present invention will now be described by way of example and not by way of limitation with reference to the accompanying drawings.

Brief description of the drawings

Fig. 1 is a fragmentary cross-sectional view of one embodiment of the ultrasonic atomizing vibrating element according to the present invention;

Fig. 2 is a cross-sectional view of an ultrasonic atomizing apparatus incorporating the vibrating element according to this invention;

Figs. 3 to 5 and 7 are fragmentary cross-sectional views of further forms of ultrasonic atomizing vibrating element according to this invention; and

Fig. 6 is a cross-sectional view of an ultrasonic atomizing apparatus incorporating the vibrating element shown in Fig. 5.

Description of the embodiments shown in the drawings

Fig. 2 illustrates an ultrasonic atomizing apparatus with which a vibrating element according to this invention is used. While the present invention may be suitably used in ultrasonic atomizing apparatus for the various applications as indicated hereinabove, it is described here with reference to a fuel nozzle for a gas turbine engine.

The nozzle includes a generally cylindrical elongated valve body 8 having a bore 6 extending through the center thereof. Disposed extending through the central bore 6 is a vibrating element 1 which includes an upper body portion 1a, an elongated cylindrical vibrator shank 1b having a diameter smaller than that of the body portion 1a, and a transition portion 1c connecting the body portion 1a and the shank 1b. The body portion 1a has an enlarged diameter flange 1d which is attached to the valve body 8 by a shoulder 12 formed in the upper end of the valve body and an

annular vibrator retainer 14 fastened to the upper end face of the valve body by bolts (not shown).

The forward end of the vibrating element 1, that is, the forward end of the shank 1b is formed with an edged portion 2A the details of which will be described below. The valve body 8 is formed through its lower portion with one or more supply passages 4 for feeding said edged portion 2A with fuel. The fuel inlet port 16 of the supply passage 4 is fed with liquid fuel through an exterior supply line (not shown) from an external source of fuel (not shown). The flow and flow rate of fuel are controlled by a supply valve (not shown) disposed in the exterior supply line.

With the construction described above, the vibrating element 1 is continuously vibrated by an ultrasonic generator 100 operatively connected to the body portion 1a. Liquid fuel is thus supplied through the exterior line, the supply valve and the supply passage 4 to the edged portion 2A where the fuel is pulverized and discharged out.

One embodiment of the vibrating element according to this invention is illustrated in Fig. 1. The vibrating element 1A in this embodiment has an edged portion 2A comprising a helical screw thread or threads of uniform diameter formed in the forward or lower end portion of the element. While the screw thread or threads may be of any desired shape, provided that they define an edged portion, a triangular thread may be usually employed with the angle of thread in the range of 10 to 150°. The pitch P of thread may be usually about 0.5 mm but is not limited thereto. For the total length or height h of the edged portion 2A in the range of 1 mm to 3 cm, the pitch P may be such that the number of thread turns will be two to six and preferably two to eight. While the screw thread is shown as a single flight screw in the illustrated embodiment, it may be any multiple thread screw such as a two- to four-start screw, for example. Of importance is it that the geometry of the helical grooves or screw threads as shown in Fig. 1 be such as to be able to reduce the liquid fuel to a thin film at each edge and to impart vibration to the liquid crossing each edge.

As indicated above, the edged portion 2A of the vibrating element according to this invention is formed around its outer periphery with one or more helically extending edges which facilitate smooth flow of the liquid in a generally axial direction of the element 1A. In addition, the entire edged portion may be effectively utilized to increase the vibrating surface area effective for pulverization, resulting in a great increase in the amount of spray being produced as well as providing very stable and consistent conditions in which the spray is produced.

With the construction described above, as liquid, which is fuel in the illustrated embodiment, is passed to the edged portion 2A, the stream of fuel is severed and pulverized at the screw thread edge due to the vertical vibrations imparted to the vibrating element 1A. Fuel is first partially pulverized at the screw thread crest or edge adjacent to the liquid supply port, and the excess portion of the fuel which has not been so pulverized at said screw thread edge flows axially down, across the helical screw groove, and helically down along the helical screw groove to be handled and pulverized by a downstream screw thread edge. It is to be understood that at a higher flow rate of fuel a larger effective surface area is required for pulverization, requiring a longer helical thread or threads. At a lower flow rate, however, only a shorter helical thread is required to complete the pulverization of fuel. Thus, with the vibrating element 1A according to this invention, the length of the screw thread or threads required for pulverization will vary with changes in the flow rate so as to provide generally uniform conditions such as the thickness of liquid film at every location where the pulverization takes place, resulting in uniform particle size of the droplets being pulverized. In addition, this vibrating element accommodates a full range of flow rates usually required for pulverization, so that pulverization of various types of liquid material may be accomplished, whether it may be on an intermittent basis or a continuous basis. Further, as explained above, supply of liquid to the edged portion is continuously effected *via* the screw thread groove or grooves to ensure a very consistent spray process.

A vibrating element 1B according to this invention is shown in Fig. 3. This has an edged portion 2B provided by a screw thread or threads having progressively decreasing outer diameters. Alternatively these screw thread or threads may have progressively increasing outer diameters.

Fig. 4 illustrates a vibrating element 1C having an edged portion 2C of stepped form in which the riser or vertical wall of each step is formed with a screw thread or screw threads to define a great number of edges.

Fig. 5 shows a vibrating element 1D in which the edged portion 2D is formed around the inner periphery of the forward end portion of the vibrating element. As shown in Fig. 6, in an injection nozzle 10 incorporating such vibrating element 1D, liquid is supplied to the edged portion 2D through a liquid supply passage 4 formed through the vibrating element. A fuel supply port 18 is provided in the vibrating element 1D at a location where the amplitude of vibration is minimal, that is, at a node. Accordingly, the fuel supply port 18 would actually be positioned well below the position shown in Fig. 6.

Fig. 7 illustrates an embodiment further modified from the vibrating elements shown in Fig. 5. The vibrating element 1E in this embodiment has an edged portion 2E formed by a screw thread or threads of progressively increasing diameter.

The geometry of the screw threads comprising the edged portions 2B to 2E of the vibrating elements 1B—1E is designed in a manner similar to that described with reference to the vibrating element 1A of Fig. 1.

An actual example of various parameters and dimensions applicable to the ultrasonic injection nozzle utilizing a vibrating element according to this invention are as follows:

Output of ultrasonic vibration generating means:	10 watts
Amplitude of vibrating element:	34 µm
Frequency of vibration:	38 KHz

Geometry of vibrating element (shown in Fig. 1)

Outer diameter of screw thread:	7 mm
Shape of thread:	Triangular thread
Included angle:	60°
Number of thread turns:	5
Length of threaded portion:	1 cm
Type of fuel:	Kerosine
Flow rate of fuel:	10 cm^3/S
Injection pressure:	5 kg/cm^3
Temperature of fuel:	Normal temperature
Material of which vibrating element is made:	Titanium

Effects of the invention

As explained hereinabove, it is to be appreciated that a vibrating element according to this invention provides for supplying a large quantity of liquid in a stable and consistent manner, as compared to the prior art vibrating element used on the conventional injection nozzle or ultrasonic injection nozzle, and provides a large capacity for stable pulverization with no substantial changes in the pulverization conditions such as flow rate and particle size depending upon the properties, particularly the viscosity of supply liquid. Further, the vibrating element of this invention does not exhibit deterioration in the quality of pulverization even at a low flow rate.

Claims

1. A vibrating element (1A; 1B; 1C; 1D; 1E) for ultrasonic atomization having an edged portion (2A; 2B; 2C; 2D; 2E) formed around an inner or an outer periphery of an outer end of the element, to be supplied with liquid to be pulverized, said edged portion having projecting steps each defining an edge, the edges of the steps, in the case of inner peripheral steps, having the same or progressively increasing diameters, the steps being formed by helical screw thread turns.

2. A vibrating element (1A) as claimed in claim 1 in which the steps are outer peripheral steps the edges of which have the same diameter.

3. A vibrating element (1B) as claimed in claim 1 in which the steps are outer peripheral steps the edges of which have progressively decreasing diameters.

4. A vibrating element (1C) as claimed in claim 1 in which the steps are outer peripheral steps arranged in groups of steps the edges of which have the same diameter, the edges of the step groups having progressively decreasing diameters.

Patentansprüche

1. Schwingungsglied (1A; 1B; 1C; 1D; 1E) zur Ultraschallzerstäubung mit einem Kantenbereich (2A; 2B; 2C; 2D; 2E), der um einen Innen- oder einen Außenumfang eines äußeren Endes des Schwingungsglieds gebildet und dem zu zerstäubende Flüssigkeit zuzuführen ist, wobei der Kantenbereich jeweils eine Kante bildende vorspringende Stufen aufweist, die Kanten der Stufen, im Falle von Innenumfangsstufen, den gleichen oder fortschreitend größer werdende Durchmesser besitzen und die Stufen von Schraubengewindegängen gebildet sind.

2. Schwingungsglied (1A) nach Anspruch 1, bei dem die Stufen Außenumfangsstufen sind, deren Kanten den gleichen Durchmesser aufweisen.

3. Schwingungsglied (1B) nach Anspruch 1, bei dem die Stufen Außenumfangsstufen sind, deren Kanten fortschreitend kleiner werdende Durchmesser aufweisen.

4. Schwingungsglied (1C) nach Anspruch 1, bei dem die Stufen Außenumfangsstufen sind, die in Stufengruppen angeordnet sind, deren Kanten den gleichen Durchmesser aufweisen, und wobei die Kanten der Stufengruppen fortschreitend kleiner werdende Durchmesser besitzen.

Revendications

1. Elément vibrant (1A 1B 1C 1D 1E) pour une pulvérisation ultrasonore comportant une portion à aretes (2A 2B 2C 2D 2E) formée autour d'une périphérie interne ou d'une périphérie externe d'une extrémité externe de l'élément, cette portion à arêtes devant être alimentée avec le liquide à pulvériser, cette portion à arêtes comportant des gradins en saillie définissant chacun une arête les arêtes des gradins dans le cas de gradins périphériqeus internes, ayant le même diamètre ou des diamètres allant en croissant progressivement les gradins étant formés par des spires de filets de vis hélicoidaux.

2. Elément vibrant (1A) suivant la revendication 1 caractérisé en ce que les gradins sont des gradins périphériques externes dont les arêtes ont le même diamètre.

3. Elément vibrant (1B) suivant la revendication 1 caractérisé en ce que les gradins sont des gradins périphériques externes dont les arêtes ont des diamètres allant en diminuant progressivement.

4. Elément vibrant (1C) suivant la revendication 1 caractérisé en ce que les gradins sont des gradins périphériques externes disposés en groupes de gradins dont les arêtes ont le même diamètre, les arêtes des groupes de gradins ayant des diamètres allant en diminuant progressivement.

FIG.1

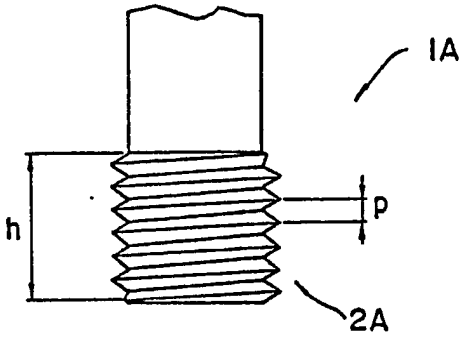

FIG.2

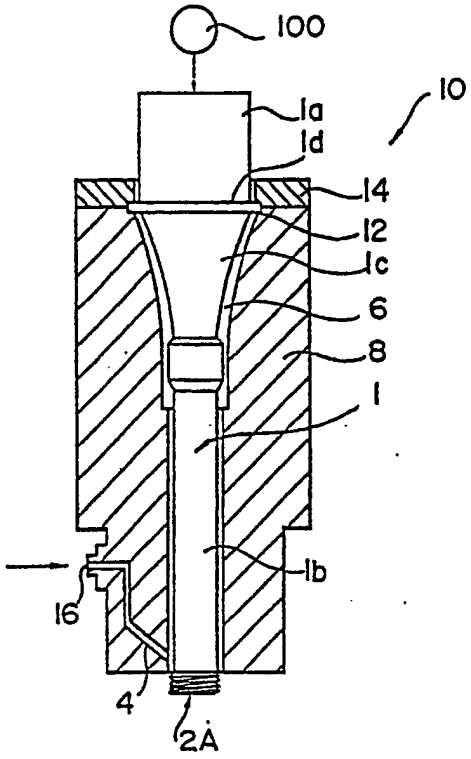

FIG.3

3

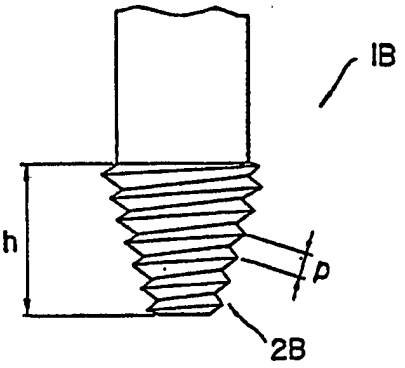

FIG.4

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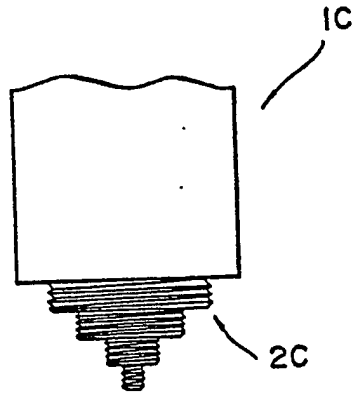

FIG.5

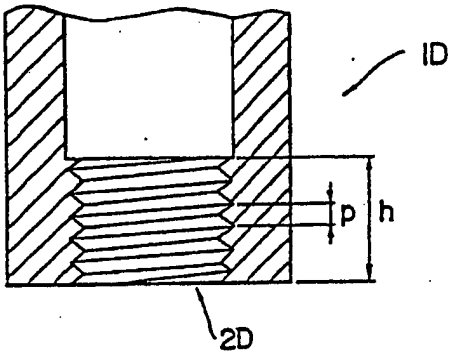

FIG.6

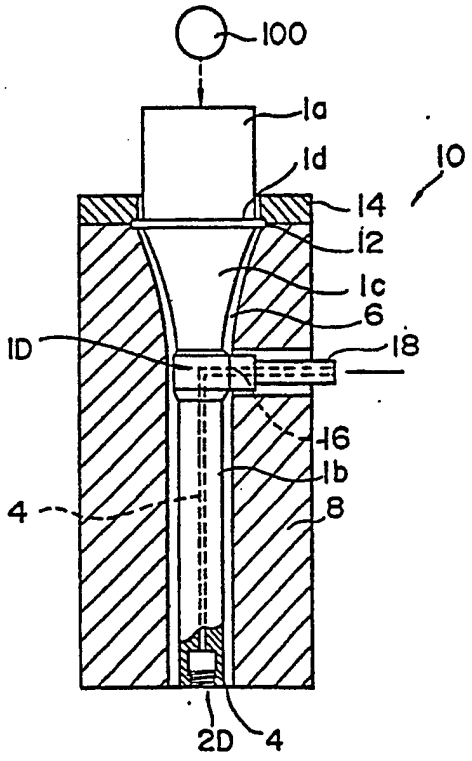

FIG.7

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